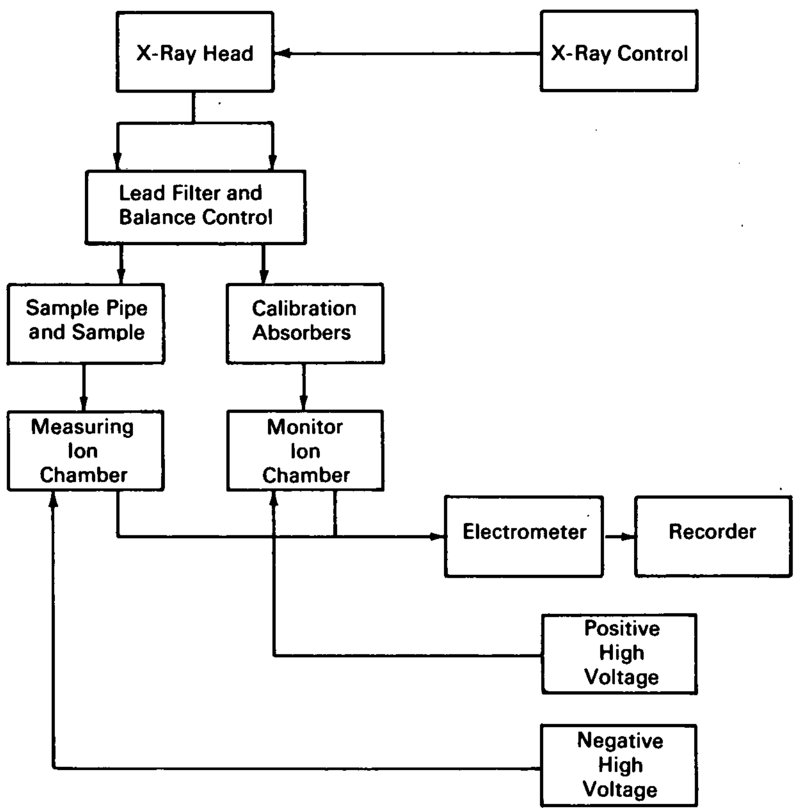
NASA TECH BRIEF

Densitometer System for Liquid Hydrogen Has High Accuracy, Fast Response



The problem:

To design a density measuring system for cryogenic liquids using an ionization-type detector with X-rays as the radiation source. The system must be capable of measuring the density of liquid hydrogen in vacuum jacketed lines having an inside diameter of up to 6 inches within an accuracy of 0.1 percent of the absolute density of the liquid in less than 1 second. Conventional density and thickness gages using an X-ray generator and dual ionization detectors do not meet the requirements for speed and accuracy.

The solution:

A developmental densitometer system in which the X-rays are heavily filtered with a lead shield to make the energy spectrum much less dependent on the voltage applied to the X-ray tube and which uses two balanced ionization chambers containing xenon gas,

(continued overleaf)

instead of an electronegative gas, to reduce both temperature and voltage effects.

How it's done:

The X-rays from the X-ray head are passed into the lead filter, which may be rotated slightly to change its effective thickness and thus to control the radiation fields at the two ionization chambers. One of the filtered X-ray beams is passed to the measuring ion chamber via the sample pipe and the sample to be measured. The second radiation beam is simultaneously passed through the calibration absorbers to the monitor ion chamber. These absorbers are chosen to have essentially the same effect on the X-ray radiation as the sample pipe and the sample at midscale density. At this density, the output currents from the two chambers can be made to cancel over a wide range of X-ray intensities generated at the X-ray head. Any change in the density of the sample from the midscale calibration value will result in a difference current appearing at the input to the electrometer. This signal current is integrated at the electrometer input, amplified, and displayed on an output recorder as a density change. Because of the high sensitivity of the xenon ion chambers at low energies, and the high intensity X-ray fields available, the statistical noise in the signal is low enough to provide a time constant of 0.25 second, giving system response times of less than 1 second. Power supplies of opposite polarity are used for the two ion chambers to facilitate cancellation of the output currents at the midscale density value. The electrometer, recorder, power supplies, and X-ray control are remotely located from the X-ray head, with suitable intervening shielding.

Notes:

1. Tests employing liquid hydrogen in 6-inch vacuum jacketed lines indicate that the system under development is capable of yielding density data in a response time of less than 1 second, with a 1-sigma sensitivity of $\pm 2.27 \times 10^{-5}$ kilogram per liter and an absolute accuracy of 7×10^{-5} kilogram per liter.
2. With minor modification, the system may be used with other cryogenic liquids, including liquid fluorine and liquid oxygen.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10438

Patent status:

No patent action is contemplated by NASA.

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